

Orbitals, configurations and ionisation energy patterns

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Lab answers

The model answers use $h = 6.626 \times 10^{-34} \text{ J s}$, $c = 3.00 \times 10^8 \text{ m/s}$ and Avogadro's constant $6.022 \times 10^{23} \text{ mol}^{-1}$. Small differences in the last figure come from rounding.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.1.1, IB S1.3

Question 1 Photon energy of sodium

$E = (6.626 \times 10^{-34} \times 3.00 \times 10^8) \div (589 \times 10^{-9}) = 1.9878 \times 10^{-25} \div 5.89 \times 10^{-7} = \mathbf{3.37 \times 10^{-19} \text{ J}}$.

Question 2 Energy per mole

$3.37 \times 10^{-19} \text{ J} \times 6.022 \times 10^{23} \text{ mol}^{-1} = 2.03 \times 10^5 \text{ J mol}^{-1} = \mathbf{203 \text{ kJ mol}^{-1}}$.

Question 3 Completing the calculation

Lithium: $E = 1.9878 \times 10^{-25} \div 6.70 \times 10^{-7} = 2.97 \times 10^{-19} \text{ J}$, which is **179 kJ mol⁻¹**.

Potassium: $E = 1.9878 \times 10^{-25} \div 7.67 \times 10^{-7} = 2.59 \times 10^{-19} \text{ J}$, which is **156 kJ mol⁻¹**.

Question 4 Origin of the colours

Heat gives electrons in the ion enough energy to jump to a higher energy level (excitation). They fall back to lower levels and emit the energy difference as a photon. Each ion has its own set of energy gaps, so it emits its own wavelengths and **its own colour**.

Question 5 Comparison with ionisation

The photon value (203 kJ mol^{-1}) is **much smaller than 496 kJ mol^{-1}** . The electron only moves between two levels of the atom (3p to 3s), whereas ionisation removes it completely, which needs far more energy. The ratio is 2.4.

Question 6 Reliability

Percentage uncertainty = $5 \div 589 \times 100 = \mathbf{0.85 \%}$. Energy uncertainty = $0.85 \% \times 203 \text{ kJ mol}^{-1} = \mathbf{\pm 1.7 \text{ kJ mol}^{-1}}$.

Question 7 Improving the method

Use a narrower slit or a calibrated spectrometer, check the scale against a known line such as the sodium yellow line, and repeat each reading several times to take a mean.